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Indian Standard

EXPRESSION OF THE PROPERTIES OF SAMPLING OSCILLOSCOPES

INDIAN STANDARDS INSTITUTION

UDC 621·317·75

Indian Standard

EXPRESSION OF THE PROPERTIES OF SAMPLING OSCILLOSCOPES

National Foreword

This Indian Standard, which is identical with IEC Pub 548-1976 'Expression of the properties of sampling oscilloscopes', issued by the International Electrotechnical Commission (IEC), was adopted by the Indian Standards Institution on the recommendation of the Electronic Measuring Equipment Sectional Committee and approved by the Electronics and Telecommunication Division Council.

Cross Reference

International Standard	*Corresponding Indian Standard*
IEC Pub 348-1978 Safety requirements for electronic measuring equipment (*second edition*)	IS : 9858-1981 Safety requirements for electronic measuring equipment (Technically equivalent)
IEC Pub 351-1-1976 Expression of the properties of cathode-ray oscilloscopes Part 1 General	IS : 11018 (Part 1)-1984 Expression of the properties of cathode-ray oscilloscopes : Part 1 General (Identical)
IEC Pub 359-1971 Expression of the functional performance of electronic measuring equipment	IS : 9176-1979 Method for specifying the functional performance of the electronic measuring equipment (Technically equivalent)

Note — The French text given in the IEC Publication has been dropped while adopting the publication as Indian Standard.

Electronic Measuring Equipment Sectional Committee, LTDC 21 [Ref : Doc : LTDC 21 (674)]

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1. Scope

1.1 This standard applies to equivalent-time sampling oscilloscopes for measuring electrical quantities.

Note. — At lower sweep rates some equivalent-time sampling oscilloscopes may operate in a real-time sampling mode.

1.2 This standard is also applicable to:

— multi-trace sampling oscilloscopes when they comply with Sub-clause 1.1;
— complete assemblies comprising sampling oscilloscopes with detachable or incorporated parts, e.g. probes or interchangeable plug-in units.

1.3 This standard applies also to oscilloscopes for measuring non-electrical quantities when it is possible to express their performance in terms of an electrical quantity which represents the non-electrical quantity.

1.4 This standard is concerned with the qualities of the cathode-ray tubes only when these are necessary for the evaluation of oscilloscopes. The intrinsic qualities of cathode-ray tubes will be dealt with in another standard.

1.5 Some portions of this standard may be applicable, by special agreement between manufacturer and user, to the other types of sampling oscilloscopes; for instance, real-time sampling oscilloscopes or those using digital displays or programmable units.

2. Object

The object of this standard is the standardization of methods of expression of the properties of sampling oscilloscopes and more particularly:

— the definition of special terminology and catalogue data related to these types of apparatus;

— the specification of conditions and methods for testing these types of apparatus in order to verify their compliance with properties claimed or specified by the manufacturer.

2.1 Safety requirements are not dealt with in this standard. Unless otherwise agreed upon, devices such as those in Clause 1 shall comply with IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus.

SECTION ONE — DEFINITIONS

For the purpose of this standard, it has been agreed that the special meanings contained in the following clauses shall apply. Definitions taken from the International Electrotechnical Vocabulary are shown by the reference I.E.V.

3. Types of oscilloscopes

3.1 *Cathode-ray oscilloscope*

An apparatus for measurement or observation purposes which uses the deflection of one or more electron beams to produce a display which represents the instantaneous value of functions of varying quantities, one of them in general being time.

3.2 *Sampling oscilloscope*

An oscilloscope which employs signal sampling together with means for constructing a coherent display from the samples taken.

Note. — Sampling oscilloscopes may use sequential sampling or random sampling (see Sub-clauses 4.2 and 4.3) and the display may be represented in equivalent time or in real time (see Sub-clauses 4.4 and 4.5).

3.3 *X–Y sampling oscilloscope*

A sampling oscilloscope in which two components of a phenomenon are sampled by two channels; the first determines the vertical deflection of the dots, the other the horizontal deflection.

4. Terms fundamental to the sampling process

4.1 *Sampling*

A process of sensing and storing one or more instantaneous values of a signal for further processing or display.

4.2 *Sequential sampling*

A sampling process in which samples are taken at successively later (or earlier, according to the process involved) times relative to the trigger recognition point (see Sub-clause 7.6).

4.3 *Random sampling*

A sampling process allowing a significant time-interval uncertainty between the signal and sample-taking operation. Also the process of coherent display construction from such randomly taken samples.

4.4 *Equivalent-time sampling*

A sampling process in which no more than one sample is taken during one occurrence of that portion of the input signal which is to be displayed. The real duration of the sweep is equal to the time required for several repetitions of the input signal.

4.5 *Equivalent-time sampling display*

A display constructed by means of equivalent-time sampling.

4.6 *Equivalent-time*

The time scale associated with a display constructed by an equivalent-time sampling process.

4.7 *Real-time sampling*

A sampling process in which more than one sample is taken during each occurrence of that portion of the input signal which is to be displayed. The real duration of the sweep is equal to the real duration of that portion of the input signal.

4.8 *Real time*

The time scale associated with a display constructed by a real-time sampling process.

4.9 *Sample*

That part of the input signal which is taken during the operation of the sampling gate (see Sub-clause 6.3).

4.10 *Feed-through sampler*

A signal-path configuration in which the input signal is conducted past the sampling gate to be made available for further use or external termination.

4.11 *Sample distribution*

In a random sampling oscilloscope, a mathematical function of equivalent time which describes how the density of randomly placed samples varies along the trace.

4.12 *Probability distribution of samples*

The average number of samples that fall left of a chosen point on the equivalent time axis, divided by the total average number of samples, both being averaged for the same length of real time.

Note. — The probability distribution of samples is a function of the equivalent time; it starts from zero, ends at unity and has only positive or zero slopes.

4.13 *Probability density of samples*

The average number of samples falling within a relatively narrow (in comparison with the length of equivalent time for which it is averaged) equivalent-time interval, divided by the total average number of samples, both being averaged for the same length of real time.

Note. — The probability density of samples generally depends on where the chosen narrow interval lies on the equivalent-time axis and is, therefore, a function of the equivalent time. Mathematically, it is the derivative of the probability distribution function, and the area under the curve is equal to unity.

4.14 *Dot transient response*

The ability of a sampling oscilloscope to display a change in two successively sampled values of the input signal.

Note. — Dot transient response depends on smoothing (see Sub-clause 6.13).

5. Cathode-ray tube

5.1 *Cathode-ray tube*

An electron-beam tube in which the beam can be focused to a small cross-section on a surface and varied in position and intensity to produce a pattern either visible or otherwise detectable (I.E.V. 07-30-090).

5.2 *Cathode-ray tube size*

The overall dimension of the face of the cathode-ray tube (external diameter of tubes with a circular face, the height and width of tubes having a rectangular face).

5.3 *Screen*

The surface of the tube upon which the visible pattern is produced (I.E.V. 07-30-145).

5.4 *Spot*

The small area of the screen surface instantaneously affected by the impact of the electron beam (I.E.V. 07-30-160).

5.5 *Spot size and focus*

Under consideration.

5.6 *Measuring area*

That part of the screen within which measurements can be made with defined accuracy.

Note. — This is not necessarily the whole screen area within which a display can be obtained.

6. Terms related to the sampling loop

a) Terms related to sampling loop techniques

6.1 *Feedback sampler*

A sampling system employing a feedback sampling loop.

6.2 *Sampling loop*

The feedback system which is established to improve linearity and accuracy by operating the sampling gate as a null detector.

Note. — The sampling loop, in general, will consist of those items defined in Sub-clauses 6.3, 6.4, 6.5, 6.6, 6.7 and 6.8.

6.3 *Sampling gate*

A switch, usually electronic, which operates briefly upon command for the purpose of sampling the input signal.

6.4 *Balanced sampling gate*

A type of sampling gate arranged symmetrically so that the strobe signals are balanced.

6.5 *Forward attenuator*

A circuit which determines forward gain and is normally ganged with the feedback attenuator.

6.6 *Sample-and-hold gate*

A switch, usually electronic, between a sample-and-hold circuit and its driving amplifier.

6.7 *Sample-and-hold circuit*

A circuit which stores the vertical (or horizontal) co-ordinate value of a sample.

6.8 *Feedback attenuator*

A circuit which determines attenuation of the feedback signal in the sampling loop.

b) Terms relating to sampling loop performance

6.9 *Loop gain*

The product of sampling gate efficiency, forward gain and feedback attenuation.

6.10 *Forward gain*

The effective gain between the sampling gate output and the sample-and-hold output.

6.11 *Feedback attenuation*

In a sampling loop, the effective attenuation in the signal path between sample-and-hold output and sampling gate.

6.12 *Sampling gate efficiency*

The ratio of the gate output voltage change between the instant before sampling (t^-) and the instant after sampling (t^+) to the difference between the gate input voltage (E_i) and gate output voltage (E_o) at the instant before sampling (t^-) expressed as a percentage.

$$\text{Sampling gate efficiency} = \frac{E_o(t^+) - E_o(t^-)}{E_i(t^-) - E_o(t^-)} \times 100\%$$

6.13 *Smoothing*

A process affecting dot transient response wherein sampling loop gain is purposely made to be less than unity in order to reduce the effects of random noise and horizontal jitter.

7. **Terms related to the slewing process** (see Figure 1, page 92)

7.1 *Slewing*

The process of causing successive samples to be taken at different instants relative to the trigger recognition point. This term also applies to sequential sampling and to random sampling.

7.2 *Scanning*

The process by which slewing is controlled.

Note. — The function performed is the association of the time function of the input signal with the horizontal position function of the spot. In an equivalent-time sampling oscilloscope, it is governed by the scanning signal.

7.3 *Scanning signal (scanning ramp, slow ramp)*

A staircase, ramp or other changing voltage which governs the horizontal deflection of the spot and directly or proportionately interacts with the slewing ramp.

7.4 *Slewing ramp (fast ramp)*

A linear ramp which interacts with the scanning signal to cause slewing.

7.5 *Trigger recognition*

The process of responding to a suitable triggering signal (see Sub-clause 14.6 and Figure 1, page 92).

7.6 *Trigger recognition point*

The point in time at which trigger recognition occurs, also that point on a display waveform representing the instant of trigger recognition (see Sub-clause 14.6).

7.7 *Sampling command*

A general term relating to a trigger or other electrical signal intended to cause sampling.

7.8 *Strobe*

A pulse of short duration which directly operates the sampling gate.

7.9 *Slewing interval*

The particular equivalent-time interval over which the scanning signal allows sampling to occur.

8. Terms related to the presentation of the display

8.1 *Dot*

A spot, the position of which indicates the horizontal and vertical co-ordinates of a particular sample.

8.2 *Dot density*

The number of dots per centimetre without input signal.

8.3 *Coherent display*

A display in which the time function of the input signal is preserved. A coherent display may be produced by either random or sequential sampling.

8.4 *False display*

A sampling display allowing faulty or ambiguous interpretation, usually caused by insufficient dot density, improper triggering, or improper setting of the controls.

8.5 *Magnified display (expanded display)*

When associated with sweep timing or horizontal deflection, a display whose time per division has been decreased. Usually produced either by attenuation of the scanning signal or by amplification of the horizontal deflection signal.

8.6 *Display window*

The equivalent-time interval represented within the limits of the rated horizontal deflection.

8.7 *Time positioning*

The process of moving the display window by, for example, offsetting the d.c. level of the scanning signal or of the slewing ramp.

8.8 *Time position range*

The equivalent-time interval over which the display window can be moved by time positioning.

9. General terms concerning waveform

9.1 *Departures from a sinewave*

The distortion of a sinewave is defined by its crest factor and/or by limits β defined by the formula:

$$y = a(1 - \beta) \sin \omega t < y < a(1 + \beta) \sin \omega t$$

Note. — When the value assigned to the quantity β is especially significant, it is necessary, in addition, to establish a limit for the difference between the peak value and $\sqrt{2}$ times the r.m.s. value.

9.2 *Square wave*

A periodic wave that alternately assumes two fixed values for equal lengths of time, the time of transition being negligible in comparison with the half-length (I.E.V. 55-35-090).

9.3 *Rectangular pulse*

A waveform having a profile approximately rectangular, the rise and fall times being sufficiently short in comparison with the pulse duration (from I.E.V. 55-35-085).

10. Terms concerning preparation of tests

10.1 *Warm-up time*

The time interval after switching on the oscilloscope under reference conditions necessary for it to comply with all accuracy requirements.

10.2 *Adjustment*

The operation by means of which certain adjusting parts are set according to the manufacturer's directions, so as to cause the oscilloscope to conform with the specified accuracy.

Note. — This process is termed *preliminary adjustment* when it is carried out before tests, and *readjustment* during tests.

With oscilloscopes having built-in calibrating devices, calibration may form a part of preliminary adjustments.

10.3 *Centring*

The process by which the spot (or the base line drawn by the spot) is adjusted to a definite place on the screen.

11. Terms related to accuracy

a) Quantities related to the function of the oscilloscope and terms related to conditions of operation, transport and storage

11.1 *Performance characteristic*

One of the quantities assigned to an oscilloscope in order to define by values, tolerances, ranges, etc., the performance of the oscilloscope.

Note. — The term "performance characteristic" does not include influence quantities (see Note to Sub-clause 11.2).

11.2 *Influence quantity*

Any quantity, generally external to an oscilloscope, which may affect the performance of the oscilloscope.

Note. — Where a change in a performance characteristic affects another performance characteristic, it is referred to as an *influencing characteristic* (see Sub-clause 11.23).

11.3 *Reference value*

A single value of an influence quantity at which the oscilloscope (or accessory) complies with the requirements concerning intrinsic errors.

11.4 *Reference range*

A range of values of an influence quantity within which the oscilloscope (or accessory) complies with the requirements concerning intrinsic errors.

11.5 *Reference conditions*

A set of values with tolerances (reference values), or of restricted ranges (reference ranges) of influence quantities and, if necessary, of influencing characteristics, specified for making comparison and calibration tests.

11.6 *Rated range of use*

The range of values for an influence quantity within which the requirements concerning operating error are satisfied.

11.7 *Rated operating conditions*

The whole of the effective ranges for performance characteristics and rated ranges of use for influence quantities within which the performance of the apparatus is specified.

11.8 *Limit conditions of operation*

The whole of the ranges of values for influence quantities and performance characteristics (beyond the rated ranges of use and effective ranges respectively) within which an apparatus can function without resulting damage or degradation of performance when it is afterwards operated under rated operating conditions.

Note. — These limit conditions will, in general, include overload.

11.9 *Conditions of storage and transport*

The whole of the conditions of temperature, humidity, air pressure, vibration, shock, etc., within which the apparatus may be stored or transported in an inoperative condition, without resulting damage or degradation of performance when it is afterwards operated under rated operating conditions.

b) Values related to quantities

11.10 *Rated value*

The value (or one of the values) of a quantity to be measured, observed, supplied or set, which the manufacturer has assigned to the oscilloscope.

11.11 *Rated vertical (horizontal) deflection*

Distance measured in the vertical (horizontal) direction between the limits of the measuring area.

11.12 *Rated range*

The range of a quantity to be measured, observed, supplied or set, which the manufacturer has assigned to the oscilloscope.

11.13 *Effective range*

That part of the rated range where measurements can be made or quantities be supplied within the stated limits of error (I.E.V. 20-40-035, modified).

c) Terms related to the specification of performance

11.14 *Performance*

The degree to which the intended functions of an oscilloscope are accomplished.

Errors

11.15 *Absolute error*

The error expressed algebraically, in the unit of the measured quantity.

a) For a measuring apparatus, the error is the indicated value of the measured quantity minus its true value.

b) For a supply apparatus, the error is the true value of the quantity supplied minus its rated, indicated or preset value.

Notes 1. — The *true value* of a quantity is the ideal value that would be measured by a measuring process having no error.

In practice, since this true value cannot be determined by measurement, a ***conventionally true*** value, approaching the true value as closely as necessary (having regard to the error to be determined), is used in place of the true value. This value may be traced to standards agreed upon by the manufacturer and the user, or to national standards. In both cases, the uncertainty of the conventionally true value shall be stated.

2. — The above definitions do not apply to deflection coefficients or time coefficients of an oscilloscope as these coefficients are neither measured nor supplied quantities.

11.16 *Relative error*

The ratio of the absolute error to a stated value.

11.17 *Absolute error of a deflection (time) coefficient*

The difference between the measured value and the rated value of a deflection (time) coefficient.

Note. — The measured value of a coefficient is the value that is calculated from the deflection measured on the screen when a known signal is applied to input terminals.

11.18 *Relative error of a deflection (time) coefficient*

The ratio of the absolute error of a deflection (time) coefficient to the rated value.

11.19 *Percentage error*

The relative error expressed as a percentage.

11.20 *Relative linearity error of a coefficient*

Relative linearity error of a coefficient is given by whichever of the following two expressions has the greater value without regard to sign:

$$\frac{K_a - K_b}{K_a} \quad \text{or} \quad \frac{K_a - K_c}{K_a}$$

where:

K_a = average deflection coefficient measured over the central 80% region of the rated deflection

K_b and K_c = average deflection coefficient for each of the two extreme 10% regions of the rated deflection

Note. — This definition of linearity is intended solely for oscilloscopes and takes account of the fact that departures from linearity are generally negligible in the central 80% of the rated deflection but become significant in the extreme 10% regions.

11.21 *Intrinsic error*

The error determined under reference conditions.

11.22 *Operating error*

The error determined under rated operating conditions (see Sub-clause 11.7).

11.23 *Influence error*

The error determined when one influence quantity assumes any value within its rated range of use (or an influencing performance characteristic assumes any value within its effective range), all others being at reference conditions.

Note. — When over the whole rated range of use a substantially linear relationship exists between the influence error and the effect causing it, the relationship may be conveniently expressed in coefficient form.

11.24 *Limits of error*

The maximum values of error assigned by the manufacturer to a measured quantity of an oscilloscope operating under specified conditions.

11.25 *Limits of error of a deflection (time) coefficient*

The maximum values of error assigned by the manufacturer to a deflection (time) coefficient of an oscilloscope operating under specified conditions.

d) Variation

11.26 *Variation*

The difference between the values of a measured or supplied quantity when one influence quantity assumes successively two specified values within its rated range of use, the others being at reference conditions.

Note. — A variation may be considered as absolute or relative in the same way as an error.

12. Terms related to vertical (horizontal) deflection

a) General

12.1 *Vertical (horizontal) deflection*

The deflection of the spot when a signal is applied to the vertical (horizontal) input, the horizontal (vertical) system being non-operative.

12.2 *Vertical (horizontal) deflection coefficient*

The ratio between the voltage (current) and the length of vertical (horizontal) deflection produced by this voltage (current) (from I.E.V. 531-14-16).

Note. — Deflection coefficients are expressed by a voltage (or current) per unit length, and a coefficient of 5 V/cm is larger than 5 mV/cm. This means, accordingly, that the sensitivity with a coefficient of 5 V/cm is smaller than with a coefficient of 5 mV/cm.

12.3 *Positioning*

The vertical or horizontal movement of the trace obtained by operating the appropriate control.

b) Instability of the spot position

This term comprises the following three phenomena which may occur whether or not a signal is present.

Drift

12.4 The (unwanted) generally slow and continuous deviation of the spot as a function of time.

a) Long-term drift
Maximum deviation of the spot recorded during 1 h.

b) Short-term drift
Maximum deviation of the spot recorded during the most unfavourable minute within 1 h total recording.

Note. — Drift has, in general, vertical and horizontal components which can be measured separately, the influence quantities being held constant in every case.

12.5 *Periodic and/or random deviations (PARD)*

Unwanted deflections of a periodic (hum, ripple, etc.) and/or random (noise, fluctuation, etc.) nature due to various causes and appearing on the screen in the absence of a signal or added to the display of an input signal.

12.6 *Zero shift*

The movement of the spot without any signal, due to the effect of a prescribed change in a specified influence quantity.

Note. — The zero shift is generally not instantaneous. The maximum value of this shift shall be determined during a specified time interval.

12.7 *Tangential noise*

The voltage which, when applied to the input terminals, gives a deflection equal to that produced by PARD with the extreme 5% of the dots excluded.

c) Pulse and frequency response

12.8 *Frequency response: –3 dB bandwidth*

Band of frequencies within which the value of the reciprocal of the deflection coefficient does not differ by more than –3 dB from its value at reference frequency.

Note. — This definition does not take into account any rise or other irregularity in the frequency response between reference frequency and the –3 dB points, as this would cause irregularities concerning pulse response defined in Sub-clauses 12.9, 12.10 and 12.11.

12.9 *Rise (fall) time*

Time interval within which the current or voltage of the edge of a rectangular pulse passes from 10% to 90% (from 90% to 10%) of its steady-state amplitude (see Figure 2, page 93).

Note. — In the case of accessories and internal circuits having a proper pulse response, the following relationship between rise time (t_r) and the upper limit of the –3 dB bandwidth (B) is approximately true:

$$t_r\,(\text{ps}) = \frac{350}{B\,(\text{GHz})}$$

12.10 *Overshoot*

That part of the initial response which exceeds the steady-state value of the response to a rectangular (square) pulse (see Figure 2). It is expressed as a percentage of the steady-state value.

12.11 *Pulse tilt*

The relative difference between the initial and final amplitude of the representation of a rectangular pulse (see Figure 3*a*, page 93) or of a square wave (see Figure 3*b*, page 93) ignoring overshoot and other distortions. It is expressed as a percentage of the initial amplitude and for a specified time period:

$$\text{pulse tilt} = \frac{\Delta A}{A} \times 100 \quad \text{(Figure 3}a\text{)}$$

Note. — When tests for pulse tilt are performed with a square wave, the formula:

$$\text{pulse tilt} = \frac{2\,\Delta A}{A_2} \times 100 \quad \text{(Figure 3}b\text{)}$$

may be used for convenience.

12.12 *Signal breakthrough*

A display aberration resulting from signal-induced displacement current through the capacitance shunting the sampling gate. The characteristics of the aberration depend on the circuit time constants affecting redistribution of the displacement charge.

12.13 *Other pulse distortions*

Distortions other than those defined in Sub-clauses 12.9, 12.10, 12.11 and 12.12 are identified by the titles to Figures 4*a* to 4*g*, pages 94 and 95; verbal descriptions are not given as the diagrams are sufficient in themselves for the effects to be identified. These distortions may appear on the display either singly, in groups or combined, depending on the selected time coefficient.

When these distortions have durations comparable to the rise time *t*, the diagrams show the rise time as having finite magnitude. Conversely, when the distortion can occupy time durations up to several orders of magnitude greater than the rise time, the diagrams show the rise time as zero. This is particularly so in the case of Figure 4*g*, Defects of sustained step reponse, when the effects are thermal in origin.

d) Matching properties of the input terminals

12.14 *Input impedance of an internally terminated sampling oscilloscope*

The d.c. impedance measured at the input terminals.

Note. — When an external trigger signal is available, it is sometimes desirable to use a high impedance sampling probe which allows the sampling circuit to be placed directly at a signal source. In this case, the input impedance of the sampling probe can be represented by a resistor and a capacitor in parallel connection.

12.15 *Voltage reflection coefficient (s.w.r.)*

The ratio of the reflected and the incident voltage measured at a point along the transmission line when fed by a sinewave source and terminated by the sampling oscilloscope.

$$\varrho = \frac{\text{reflected voltage}}{\text{incident voltage}} = \frac{Z_t - Z_0}{Z_t + Z_0}$$

where:
Z_t = terminating impedance of the line
Z_0 = characteristic impedance of the line

Note. — For feed-through sampling oscilloscopes, an external termination, specified by the manufacturer, shall be used.

12.16 *Standing wave ratio (s.w.r.)*

The ratio of the maximum to the minimum voltage amplitude measured along the transmission line when fed by a sinewave source and terminated by the sampling oscilloscope (from I.E.V. 60-32-235).

$$S = \frac{E_{max}}{E_{min}} = \frac{1 + |\varrho|}{1 - |\varrho|}$$

Notes 1. — For feed-through sampling oscilloscopes, an external termination, specified by the manufacturer, shall be used.

2. — Cable inputs should be stated in s.w.r. or reflection coefficient as a function of frequency.

12.17 *Return loss*

This is 20 $\log_{10}$ of the reciprocal of the absolute value of the reflection coefficient. Expressed in decibels (from I.E.V. 55-05-195).

$$20 \log_{10} \frac{1}{|\varrho|} = 20 \log_{10} \frac{|Z_t + Z_0|}{|Z_t - Z_0|}$$

Notes 1. — For feed-through sampling oscilloscopes, an external termination, specified by the manufacturer, shall be used.

2. — The effect of a mismatch on pulse response depends on both the phase and amplitude of the voltage reflection coefficient as well as its possible changes through the passband. In simple cases when, for example, the mismatch is purely ohmic and constant as a function of frequency, the pulse distortion can be simply determined by using the above definitions. Otherwise, it is very complicated and the sinewave approach is the most practical method.

e) Interaction between circuits of an oscilloscope

12.18 *Interaction between the circuits of a multi-trace oscilloscope*

The influence of the voltage at one input on the deflection of a beam which is normally intended to display the voltage of another input.

12.19 *Interaction between x and y signals*

The effect produced by a signal applied to one deflection system on the deflection produced by another deflection system, the signals being applied to the corresponding *x* and *y* input terminals.

12.20 *Decoupling factor*

Quantity defining the suppression of interaction between any two channels of a multi-trace oscilloscope. It is the ratio between the unwanted deflection coefficient (i.e. the ratio between the amplitude of the signal of the disturbing channel to the unwanted deflection at the other channel) and the deflection coefficient of the disturbed channel.

Note. — The size of the decoupling factor is, therefore, in inverse ratio to the size of the disturbance. Decoupling factor is a number larger than 1. This means, accordingly, that the interaction corresponding to a factor of 10 000 is smaller than that corresponding to the factor 1 000.
To simplify the interpretation of this definition, the following example is given: if the two channels are numbered 1 and 2, and have individual deflection coefficients of x V/cm and y V/cm respectively, then if channel No. 1 is considered as being the disturbing one and the magnitude of the display on trace No. 1 is A cm, and if the magnitude of the display on trace No. 2 is B cm, the decoupling factor is given by the expression:

$$\frac{Ax}{By}$$

where normally $x > y$ and $A > B$.

12.21 *Phase difference between displays of a multitrace oscilloscope*

Phase difference (unwanted) observed between any two displays of a multitrace oscilloscope when the same signal is applied to both inputs.

Notes 1. — This difference may result from:
— different phase angles of the vertical deflection channels;
— different linearity errors of the separate time bases;
— different geometrical structures of deflection plates;
— phase errors caused by length difference in cables carrying the signals or strobe pulses to the sampling gate.

2. — For test purposes, it is convenient to measure the phase difference in terms of time by applying the same pulse signal to both inputs.

12.22 *Common mode rejection factor for difference amplifiers*

Relation between the deflection coefficient determined when a voltage is applied between the input terminals of the deflection circuit and the deflection coefficient determined when the same voltage is applied between the input terminals joined together and the earth terminal of the oscilloscope (from I.E.V. 70-25-050).

Note. — The common mode rejection factor is a measure of the ability of a circuit to reject interference and its size is, therefore, in inverse ratio to the size of the disturbance. Common mode rejection factor is a number larger than 1, and a common mode rejection factor of 10 000 is larger than 1000. This means, accordingly, that the interaction with a common mode rejection factor of 10 000 is smaller than with a common mode rejection factor of 1000.

f) Spurious emissions from sampling oscilloscopes

12.23 *Strobe emission*

An undesirable signal emanating from the input connector and caused by the sample-taking process.

12.24 *Trigger emission*

A signal emanating from a trigger input connector usually coincident with the trigger recognition point.

g) Delays

12.25 *Delay line (signal)*

A transmission line, usually coaxial, intended to delay the arrival of an input signal event at the sampling gate to allow time for sweep circuits to start, thereby permitting the input signal event to be viewed in the display.

12.26 *Apparent signal delay*

The time which elapses between the moment of the appearance of the sweep and the moment when the signal trace reaches 10% of the final amplitude.

Note. — The apparent signal delay is not to be mistaken for the actual signal delay, which is the time elapsing between the application of a signal voltage at the input of the oscilloscope and the time of the appearance of the signal display on the screen.

13. Terms related to the time base

13.1 *Time base*

The circuitry by which a spot displacement depending upon time is obtained.

Note. — The term "sweep" is reserved for the spot displacement produced by the time base.

13.2 *Free running time base*

A time base running periodically even in the absence of a signal.

Note. — A free running time base may be synchronized either externally or internally.

13.3 *Triggered time base*

A time base in which the trigger recognition circuit is triggered in order to provide a stable display.

Note. — In the absence of an input signal, it produces no trace.

13.4 *Sweep*

Spot displacement produced by the action of the time base.

13.5 *Single sweep operation (of a sampling oscilloscope)*

A time base function which allows one sweep only to occur allowing one single display to be constructed.

13.6 *Synchronized time base*

A free running time base which is synchronized by the input signal in order to provide a stable display.

Note. — In the synchronized mode of operation, the trigger recognition circuit *is not* triggered.

13.7 *Hold-off circuit (of a sampling oscilloscope)*

A circuit contained in the trigger and time base assembly which delays the sweep from triggering while the circuits relax to their initial conditions.

13.8 *Delayed sweep*

A sweep which is started after a defined interval of delay following a triggering pulse.

13.9 *Delaying sweep*

A sweep produced by one time base of an oscilloscope when it is used to delay the start of another sweep (delayed sweep) produced by a second time base.

13.10 *Delayed sweep operation*

An oscilloscope function involving both a delaying sweep and a delayed sweep.

Note. — A common use of delayed sweep operation follows the normal display of a signal using a particular time base. A special circuit enables the delayed sweep to be started at any (adjustable) point in time during the sweep of the first time base. A change in the operating mode of the time base then enables the signal to be displayed on a time scale provided by the delayed sweep, which may well have a much smaller sweep coefficient.

13.11 *Trace blanking; trace unblanking (or bright up)*

A process which causes the trace to be suppressed except when a dot is displayed.

Note. — Suppression may be achieved by beam current cut off or by deflecting the spot off the screen.

13.12 *Brightness*

Under consideration.

13.13 *Luminance*

Under consideration.

13.14 *Equivalent time coefficient (time coefficient)*

The ratio between the equivalent time and the corresponding distance along a sweep produced by the time base, expressed in equivalent time per unit length.

14. Terms related to display stabilization

14.1 *Display stabilization*

The process by which the display is made dependent on the observed phenomenon or on another related phenomenon, so as to construct a stable coherent display.

14.2 *Internal synchronization (or triggering)*

The synchronization (or triggering) obtained when the signal which controls the time base is supplied by an internal circuit affected by the observed quantity.

14.3 *External synchronization (or triggering)*

The synchronization (or triggering) obtained when the signal which controls the time base is applied externally and independently of the internal circuit affected by the observed quantity.

14.4 *Pre-trigger*

A triggering signal which occurs before a related signal event.

14.5 *Trigger pickoff*

A device or circuit intended to extract a portion of the input signal for use as a trigger.

14.6 *Countdown*

In a circuit receiving a recurrent triggering signal, the process of responding to only every n-th recurrence of the signal, where n is an integer which may or may not be constant.

14.7 *Trigger holdoff*

The process of restricting the maximum repetition rate at which trigger recognition can occur.

14.8 *Signal event*

Any particular signal or a portion of a signal to which special reference is made.

14.9 *Synchronization (or triggering) frequency range*

The frequency range for which the internal or external synchronization (or triggering) circuits permit a stable display to be obtained.

14.10 *Synchronization (or triggering) threshold*

The minimum peak-to-peak signal deflection in millimetres (internal) or the minimum peak-to-peak voltage of the synchronizing or trigger signal (external) which is necessary to give a stable display.

14.11 *Time-base jitter*

Unwanted fluctuations in the position of the display, or a part of it, in a direction parallel to the sweep. It is measured in real time and in equivalent time.

Note. — These fluctuations may result from:
a) an unwanted change in the trigger delay;
b) an unwanted modulation of the spot velocity.

15. **Miscellaneous**

a) Geometry and orthogonality errors and phase difference

15.1 *Geometry distortion*

A distortion appearing as a deformation of the boundary of a display, as related to the limits of the measuring area. The distortion shall be contained between the limits of the measuring area and a concentric rectangle of which the dimensions are given by the manufacturer.

15.2 *Orthogonality error*

The complement to 90° of the angle formed by a vertical and a horizontal trace measured at the centre of the measuring area.

15.3 *Parallelism error of multitrace oscilloscopes*

With cathode-ray tubes having at least two completely separated deflection systems, it is the angle between two horizontal axes and between two vertical axes measured at the centre of the measuring area.

15.4 *Phase difference between vertical and horizontal axes when used in the x-y mode*

Difference in the phase response of the vertical and horizontal deflection circuits of an oscilloscope, resulting in a departure from a purely straight line display when a sinusoidal wave is applied simultaneously to these circuits.

b) Other distortions of sampling oscilloscopes

15.5 *Dot slash*

Dot defect usually due to sample-and-hold or staircase leakage.

c) Windowing facilities

15.6 *D.C. offset*

A d.c. level which may be added to another voltage or signal. A specific use being the addition to the input signal and referred to the input terminals.

15.7 *Offset monitor*

A terminal that provides an output voltage proportional to d.c. offset voltage.

SECTION TWO — GENERAL TEST REQUIREMENTS

16. General

16.1 *Statement of limits of error*

16.1.1 Limits of operating error (which apply under rated operating conditions) shall be stated.

16.1.2 Limits of intrinsic error (which apply under reference conditions) may be stated. In the absence of a statement, they are considered to be equal to the limits of operating error.

16.1.3 Limits of influence error may be stated. It is particularly useful to state these limits when one influence quantity or influencing characteristic causes an important part of the operating error. It may also be of interest to state that certain environmental conditions do not contribute to the operating error.

16.1.4 Limits of variation may be stated when this standard explicitly permits it.

16.2 *Performance characteristics and performances to be verified*

Tests described in this standard are to be performed in order to verify compliance with the manufacturer's stated data. These tests apply to:
— vertical and horizontal deflection coefficients (see Section Four);
— time coefficients (see Section Five);
— display stabilization (see Section Six);
— other miscellaneous requirements (see Section Seven).

The clauses specify the conditions under which tests shall be performed, such as values of influence quantities, voltages to be used, switch positions of amplifiers, attenuators, etc., as well as whether these tests are mandatory or not. Recommended test methods for the determination of errors in deflection and time coefficients and for determining the displacement of the display form the object of Appendices A and B in IEC Publication 351-1, Expression of the Properties of Cathode-ray Oscilloscopes, Part 1: General.

17. Combinations of an oscilloscope with different accessories

17.1 When an oscilloscope accepts one or more plug-in devices, the assembly comprising the given plug-in devices and the oscilloscope itself is considered as a whole and shall comply with the relevant requirements for intrinsic errors and variations, as stated in the following clauses.

When another plug-in device is substituted, the new assembly shall also comply with the relevant requirements for errors and variations.

Note. — Plug-in devices for special purposes, such as time domain reflectometers, etc., are subject to a special agreement between manufacturer and user.

17.2 When an oscilloscope is supplied with a probe, the combination of oscilloscope and probe shall comply with all the requirements stated in the following clauses.

When probes are supplied as separate items and are intended to be used in combination with various types of oscilloscopes, separate specifications for the probes and for the oscilloscopes are required and these specifications should define the properties of any combination of probe and oscilloscope recommended by the manufacturer.

18. Reference waveforms

18.1 *Reference sine-waves*

The following sinusoidal waves, generally at reference frequency, are used for test purposes:

a) A sine-wave for which the coefficient β, as defined in Sub-clause 9.1, is equal to 0.01.

b) A sine-wave for which the coefficient β, as defined in Sub-clause 9.1, is equal to 0.05 but having a peak value not differing by more than 1% from $\sqrt{2}$ × the r.m.s. value.

c) A sine-wave for which the coefficient β, as defined in Sub-clause 9.1, is equal to 0.05 and having no special requirement concerning the peak value.

Note. — In certain cases, the tolerances may not be determined with sufficient accuracy. Therefore, a separate test method may be agreed upon by the manufacturer and the user, for example, based on the maximum percentage distortion of the sine-wave.

18.2 *Reference pulses*

Reference pulse characteristics are defined as a function of rise time (t_r) of the circuit to be tested (see Sub-clause 12.9).

a) Short reference pulse
Half-amplitude duration: 4 t_r
Rise time: from 0.1 t_r to 1 t_r
Maximum error in amplitude: ±5%.

b) Medium reference pulse
Duration: 10 t_r
Rise time: from 0.1 t_r to 1 t_r
Maximum error in amplitude: ±5%.

c) Long reference pulse
Duration: from 50 t_r to as long as is necessary for any particular test
Rise time: from 0.1 t_r to 25 t_r
Maximum departure from a flat top: 0.5%.

The amplitude of the long pulse is defined in terms of zones of reference as shown in Figure 6, page 96. The point A is the centre of the pulse transition and the reference zones Z_1 and Z_2, each having a duration t_r, are disposed symmetrically about the point A at distances corresponding to a multiple of t_r, for example, 50 t_r.

The maximum tolerance on amplitude is defined at these zones of reference and in the portions of the pulse adjacent and takes no account of the centre of the transition.

Note. — Any aberrations which are not symmetrical or which contain time constants of more than 0.25 t_r, and which exist in the period from Z_1 to (point $A - t_r/2$) or (point $A + t_r/2$) to Z_2, add to the uncertainty of the measurement accuracy as though they represented a change in pulse amplitude of equal amount (see Figure 6, page 96).

19. Conditions for test location

Unless otherwise specified in this standard, the following conditions shall be maintained in the test location:

— temperature within the range of 15 °C to 35 °C;

— relative humidity within the range of 45% to 75%;

— air pressure within the range of 70 kN/m² to 106 kN/m² (525 mm Hg to 800 mm Hg);

— the oscilloscope shall be supplied with rated mains voltage and frequency.

Note. — The values indicated above should not be confused with those indicated in Table I for reference conditions and test conditions.

SECTION THREE — GENERAL TEST PROCEDURE

20. Test procedure

20.1 The tests specified in the following clauses are type tests applicable to the oscilloscopes which are new and ready for use, i.e. with covers and accessories, if necessary, fitted.

20.2 When carrying out type tests, each oscilloscope tested shall be subjected to each of the tests laid down in this standard, as applicable, and as agreed between manufacturer and user.

The sequence of testing is not indicated by the order of the clauses.

20.3 In general, measurements for verification shall be carried out with instruments which do not appreciably (or only calculably) affect the values to be measured. In principle, the errors in measurements made with these instruments should be negligible in comparison with the errors to be determined.

20.4 When the error of the instrument is not negligible, the following rule shall apply:

if an oscilloscope is claimed to have a limit of error of $\pm e\%$ for a given performance characteristic and the manufacturer uses for checking it an apparatus resulting in an error of measurement of $\pm n\%$, the error being checked shall remain between the limits of $\pm(e-n)\%$;

likewise, if a user checks the same oscilloscope using another apparatus which introduces an error of measurement of $\pm m\%$, he is not entitled to reject the oscilloscope if its apparent error exceeds the limits of $\pm e\%$, but remains within the limits of $\pm(e+m)\%$.

21. General conditions for test purposes

Tests are carried out under the conditions given in the sub-clauses below and, if agreed between manufacturer and user, under that combination of conditions which may be expected to result in the maximum operating errors.

21.1 *Recommended standard values and ranges of influence quantities*

21.1.1 The reference values or ranges, the rated ranges of use and the limit ranges of operation, storage and transport, for all influence quantities shall be stated by the manufacturer and shall be selected from one of the usage groups I, II or III in Clause 6 of IEC Publication 359, Expression of the Functional Performance of Electronic Measuring Equipment. Any exceptions to the values given there shall be explicitly and clearly stated by the manufacturer with an indication that they are exceptions.

21.1.2 The oscilloscope may correspond to one group of rated ranges of use for environmental conditions and to another group for mains supply conditions, but this must be clearly stated by the manufacturer.

21.2 *Preparation for tests*

Before tests are performed, the following shall be verified:

— adjustments, if any, shall have been performed according to the manufacturer's instructions;

— before being switched on, the oscilloscope shall be in equilibrium with the temperature and humidity of the ambient air;

— the oscilloscope shall be operated at the rated supply voltage for a period equal to the warm-up time as indicated by the manufacturer; in the absence of any indication this period shall be 1 h;

— after the warm-up time, further adjustments may be made by means of the appropriate controls in accordance with the manufacturer's instructions;

— unless otherwise specified, the controls for fine adjustment and sweep expansion, if any, shall be set to the position which the manufacturer has assigned for calibrated readings;

— unless otherwise stated, the smoothing control shall be set to unsmoothed position and the dot density controls set to maximum density;

— unless otherwise stated, the d.c. offset shall be set to zero.

22. Particular conditions

The controls shall be set, and signals applied to the input, as indicated at the head of each of the applicable following sub-clauses.

When no indication is given for a control setting, it may be set to any suitable value. Unless otherwise specified, no signal is applied.

23. Reference conditions and rated conditions of use

For the purposes of tests on sampling oscilloscopes, a selection of influence quantities and influencing characteristics with their reference values and/or ranges is given in the following Table I. The values in Table I have been taken from Clause 6 of IEC Publication 359.

TABLE I

Reference conditions

Influence quantities or influencing characteristics	Reference conditions		Tolerance on reference values permitted for testing purposes
	When the reference conditions are indicated	In the absence of indication	
Ambient air temperature	20 °C, 23 °C, 25 °C, 27 °C	20 °C	±2 °C
Ambient air relative humidity	45% to 75%		
Air pressure	101.3 kPa (kN/m²)		
Supply voltage	Rated voltage		±1% for d.c. and a.c. r.m.s. ±2% for a.c. peak
Frequency of a.c. supply	Rated frequency		±1%
Electric field of external origin	*Under consideration*		
Magnetic field of external origin	*Under consideration*		
Waveform of a.c. supply voltage	Sinusoidal		Sub-clause 18.1*b)* β = 0.05 Difference between $\sqrt{2}$ × the r.m.s. value and peak-to-peak value to within ±1%
Waveform of triggering voltage	Sinusoidal		Sub-clause 18.1*c)* β = 0.05
Ripple content of d.c. voltage	Value given by the manufacturer	Negligible	Peak-to-peak value ±1% of rated voltage
Waveform of the measured signal	Sinusoidal		Sub-clause 18.1*a)* β = 0.01
Frequency of the measured signal	Reference value	1 kHz	±2%
Intensity of the electron beam		Any value between acceptable contrast and marked defocusing	
Smoothing	Indicated position	No smoothing (see Sub-clause 21.2)	
Dot density	Indicated density	Maximum (see Sub-clause 21.2)	

Rated conditions of use

The rated range of use for each of the influence quantities shall be specified by the manufacturer. The minimum requirements for the limits of the rated ranges of use are those given in Table II. The values in Table II correspond to Usage Group I in Clause 6 of IEC Publication 359.

TABLE II

Limits of rated ranges of use to apply in the absence of indication by the manufacturer

Influence quantity	Limits of the rated range of use
Duration of applied mains supply voltage	The end of the warm-up time and a time 1 h later
Mains supply voltage	± 10% for d.c. and a.c. r.m.s. ± 12% a.c. peak
Mains supply frequency	Rated value ± 5%
Ambient air temperature	+ 5 °C to + 40 °C
Frequency of the applied signal	Refer to Sub-clause 28.1

24. Determination of operating errors of oscilloscopes

The operating errors are measured under rated operating conditions stated by the manufacturer.

— Deflection coefficients are measured over the central 80% of rated deflection.

— Time coefficients are measured over the central 80% of the rated horizontal deflection.

— Linearity errors are determined by comparison between the average coefficient as specified above and the average coefficients determined for 10% of the rated deflection at both the extremities of the measuring area.

25. Determination of the influence errors and the variations of the vertical (horizontal) deflection coefficient, of the time coefficient and of the zero stability

When the oscilloscope is operated under the reference conditions shown in Table I, the influence errors or variations are determined for each influence quantity successively. The tests are performed for those influence errors or variations only where the manufacturer has specified corresponding limits. For each test, one influence quantity only is varied from its reference value (or a limit of the reference range) to the limits of its rated range of use, the other influence quantities being kept constant at their reference values or within their reference range.

25.1 The influence quantity is varied according to the following sub-clauses:

25.1.1 When a *reference value* is specified, the influence quantity is varied between that value and any value within the limits of the rated range of use.

25.1.2 When a *reference range* is specified without limits being given for the corresponding rated range of use, the oscilloscope is exempted from tests regarding the influence error for the influence quantity considered.

25.1.3 When limits of the *reference range* and of the *rated range of use* are specified, the influence quantity is varied between each of the limits of the reference range and any value of that part of the rated range of use which is adjacent to the chosen limit of the reference range.

25.2 *Influence of the duration of applied mains supply voltage*

Deflection coefficient: minimum value.
Time coefficient: a suitable value.
Signal voltage: sinusoidal at reference frequency to produce 80% of the rated deflection.

Tests on the influence of the duration of the applied supply voltage are made immediately following warm-up time.

The influence error of deflection and time coefficients is determined over a one-hour period.

The tests are made by applying the signal to be measured at the beginning and at the end of the one-hour period, for a time just sufficient for the readings to be taken and without further adjustment of any control other than recentring, if required.

25.3 *Influence of mains supply voltage*

Deflection coefficient: minimum value.
Time coefficient: a suitable value.
Signal voltage: sinusoidal at reference frequency to produce 80% of the rated deflection.

The tests are made by increasing in less than 0.1 s the supply voltage by 10% from its rated value.

The following measurements shall be recorded:

a) During the first minute
— the maximum shift of the display;
— the maximum variation of the coefficients.

b) After 15 min
— the shift of the display;
— the variation of the deflection coefficient after recentring;
— the variation of time coefficient.

The same tests are then made for a reduction of 10% from the rated value of the supply voltage.

25.4 *Influence of mains supply frequency*

Deflection coefficient: minimum value.
Time coefficient: a suitable value.
Signal voltage: sinusoidal at reference frequency to produce 80% of the rated deflection.

The influence errors of coefficients are recorded after recentring. The change of frequency will be made within 1 min, and the readings are made 15 min after the beginning of the change, after recentring.

25.5 *Influence of ambient air temperature*

Deflection coefficient: minimum value.
Time coefficient: a suitable value.
Signal voltage: sinusoidal at reference frequency to produce 80% of the rated deflection.

The influence errors of coefficients are recorded before readjustment and after recentring.

The time for changing the temperature is not laid down. The final reading shall be made when the oscilloscope is in the new thermal equilibrium.

25.6 *Influence of the frequency of measured signal*

The specification for the influence of signal frequency is given in Sub-clause 28.1.

SECTION FOUR — ERRORS OR VARIATIONS OF DEFLECTION COEFFICIENTS AND INSTABILITY OF THE SPOT POSITION

26. **Errors or variations of deflection coefficients**

26.1 *Operating error of deflection coefficients*

Deflection coefficient: all calibrated values.
Signal voltage: sinusoidal at reference frequency to produce about 80% of the rated deflection.

The error shall not exceed the limit given by the manufacturer.

26.2 *Linearity error*

Deflection coefficient: a suitable value.
Signal voltage: as appropriate, e.g. as described in Appendix A of IEC Publication 351-1.

To be compared:

a) the average deflection coefficient over the central 80% of the rated deflection;

b) the average deflection coefficients determined in either of the two extreme 10% regions of the rated deflection.

The differences shall not exceed the linearity error limits given by the manufacturer.

26.3 *Influence errors or variations of deflection coefficients*

The following tests are performed to determine:
— influence of the duration of applied mains supply voltage (see Sub-clause 25.2);
— influence of mains supply voltage (see Sub-clause 25.3);
— influence of mains supply frequency (see Sub-clause 25.4);
— influence of ambient air temperature (see Sub-clause 25.5).

These influence errors or variations shall not exceed the limits given by the manufacturer.

26.4 *Influence of magnetic fields of external origin*

Deflection coefficient: that which results in the maximum effect.

Time coefficient: a suitable value.

The influence of an external magnetic field is expressed by the ratio of the vertical deflection L resulting from a sinusoidal induction to the rated vertical deflection V_n.

The frequency of the interfering field shall be equal to the rated mains frequency of the oscilloscope unless otherwise agreed upon between manufacturer and user. It shall generate in the absence of the instrument a flux density having an r.m.s. value of 0.5 mT. In the space to be occupied by the oscilloscope, the value of the flux density shall not differ from this value by more than 10%.

The terminals of the oscilloscope being short-circuited, the latter is placed in the direction in which the effect is the maximum. The ratio L/V_n shall not exceed the limit given by the manufacturer.

Note. — It should be appreciated that induction of a much greater value than that occurring in practice is used for this test, in order to produce a convenient observation.

27. Instability of the spot position

The instability of the spot position is determined for both the vertical and horizontal directions when the oscilloscope is operated under the reference conditions of Table I.

If the drift is included in the operating error, then it is not determined separately; whereas if it is specified separately, the following test shall be made:

27.1 *Drift*

The input terminals to the deflection circuits are short-circuited and the triggering circuit is set to free-running mode. The trace is then accurately focused and the oscilloscope is allowed to function for a period of one hour. During this period the drift in the vertical direction is recorded directly.

The drift in the horizontal direction is considered to be negligible.

In the *x-y* mode of operation the drift in the horizontal direction is considered to be the same as in the vertical one.

Note. — However, if an agreement between the manufacturer and the user allows direct access to the vertical and horizontal deflection plates, a suitable recorder may be connected to the vertical (horizontal) plates and the horizontal (vertical) plates may be disconnected.

The drift is determined for the specified terms.

From the record obtained, the long- and short-term drifts are measured as shown in Figure 5, page 96.

— *The long-term drift (a)* is determined over a one-hour period beginning immediately after the end of the warm-up time. The value of the peak-to-peak excursion so determined shall not exceed the value given by the manufacturer.

— *The short-term drift (b)* is determined during a one-minute period for which the instability is a maximum, in the course of one hour. The maximum value so obtained shall not exceed the value given by the manufacturer.

Notes 1. — In general, short-term drift will be stated in millimetres, long-term drift in millimetres per hour. If values are stated in microvolts or millivolts (μV/h or mV/h), this is always referred to the smallest deflection coefficient of the oscilloscope.

2. — In the measurement of both short-term and long-term drift, periodic and/or random deviations should be ignored. It is therefore desirable that any instrument chosen to record the drift should have a time constant sufficient to minimize the effect of these quantities.

27.2 *Periodic and/or random vertical (horizontal) deviations (PARD)*

In a sampling oscilloscope, the PARD is determined by using the tangential noise measurement method (see Sub-clause 12.7).

The PARD shall be measured for both modes of operation:

— without smoothing;
— with maximum smoothing,
under the following conditions:

Vertical deflection coefficient: minimum value.

Signal voltage: none.

Time coefficient: a suitable value.

The input terminals are left open and shielded.

The tangential noise is measured as the vertical distance, expressed in volts referred to the input terminals, between two lines containing 90% of the dots of the trace, the other 10% of the dots being equally distributed above and below these two lines.

Neither of the values of tangential noise so determined (with and without smoothing) shall exceed the values stated by the manufacturer.

27.3 *Zero shift resulting from a change in supply voltage*

When the oscilloscope is subjected to the test described in Sub-clause 25.3, the display shift resulting from a change in supply voltage, measured during the first minute and 15 min after that change, shall not exceed the limits given by the manufacturer.

28. **Frequency response and rectangular pulse or square wave response**

28.1 *Response to the frequency of the signal*

Deflection coefficient: minimum value.

Signal voltage: sinusoidal, of variable frequency and of voltage necessary to obtain 80% of the rated deflection at reference frequency.

The maximum variation of the deflection coefficient is determined for changes of the frequency value between the reference value and any frequency lying within the limits of the ranges of use. These ranges are preferably:

a) the rated range of use within which the variation does not exceed the error limit of the deflection coefficient;

b) the extended range of use within which the variation does not exceed 10%;

c) the –3 dB bandwidth.

28.2 *Rise (fall) time and overshoot of a rectangular pulse*

Vertical deflection coefficient: all values.

Signal voltage: positive and negative going medium pulses as defined in Sub-clause 18.2*b)*.

Signal amplitude: to give 80% of the total rated deflection after proper positioning of the display.

During the test, the impedances of the pulse generator and input circuit of the oscilloscope, including the connecting cables, shall be matched.

The values of rise (fall) time and overshoot, when measured according to the definitions of Sub-clauses 12.9 and 12.10, shall not exceed the limits given by the manufacturer.

Notes 1. — The orthogonality error (see Sub-clause 39.2) should be taken into account when determining the rise time.

2. — If the measured rise (fall) time of a sampling oscilloscope is less than three times the rise time of the medium reference pulse, the value of rise time of the sampling oscilloscope shall be determined according to the following formula:

$$t_r = \sqrt{t_m^2 - t_p^2}$$

where:

t_r = the value of the rise time of the sampling oscilloscope
t_m = the measured rise time of the sampling oscilloscope
t_p = rise time of the medium reference pulse

28.3 *Pulse tilt*

Vertical deflection coefficient: a suitable value.

Signal voltage: long pulses in accordance with Sub-clause 18.2*c)*; the duration shall be given by the manufacturer and the rise time shall be negligible in comparison with the duration.

Signal amplitude: to give 80% of the total rated vertical deflection.

The value of pulse tilt, calculated according to Sub-clause 12.11, shall not exceed the limits stated by the manufacturer.

28.4 *Other pulse distortions*

Vertical deflection coefficient: all values.

Signal voltage:

a) medium pulses according to Sub-clause 18.2*b)*; for pulse distortions *a, b, c, d, e,* see Figures 4*a* to 4*e*, pages 94 and 95, and Sub-clause 12.13.

b) long pulses according to Sub-clause 18.2*c)*; for pulse distortions *d, f, g,* see Figures 4*d*, 4*f* and 4*g*, page 95, and Sub-clause 12.13.

Signal amplitude: to give 80% of the total rated vertical deflection.

The maximum values of pulse distortions other than overshoot shall be less than the limits given by the manufacturer.

Notes 1. — In certain types of oscilloscopes, the frequency response curve may contain peculiarities which a test with a unit step does not render sufficiently evident.

An absence of anomaly can be ensured by applying to the oscilloscope a test signal comprising a square wave of variable frequency and short rise time (in the region of t_r rise time of the circuit to be tested), but maintained constant. The square wave frequency shall be increased until the third harmonic falls beyond the upper limit of the —3 dB bandwidth, the rise time being maintained constant.

2. — The test for sustained step response is made according to Sub-clause 28.3, but with a long pulse of 1 min duration.

29. **Positioning**

29.1 *Range*

The manufacturer shall state the range of the positioning controls as a multiple of the rated vertical (horizontal) deflections.

29.2 *Range of d.c. offset*

The manufacturer shall state the maximum value of d.c. offset in volts.

30. Values of the elements of input impedance

The values of the elements of input impedance of each measuring circuit or probe shall, at the reference frequency, not differ from its rated value by more than the tolerance given by the manufacturer.

Notes 1. — At high frequencies, the values of the elements of input impedance may change to a sufficient extent to cause difficulties in using the oscilloscope. The manufacturer shall supply with the oscilloscope information showing the values of these elements as a function of frequency.

2. — When there is a possibility that negative resistance may appear at the inputs of measuring circuits or probes, the manufacturer shall state the limitations imposed on measurement.

Standing wave ratio (s.w.r.)

The manufacturer shall state the maximum value of the s.w.r.

31. Interaction between circuits of an oscilloscope

The interaction between circuits of an oscilloscope is defined by the decoupling factor. The measurement is made by successively taking each circuit as the disturbing one, the input terminals of the other circuits being left open but shielded.

31.1 *Decoupling factor of multi-trace oscilloscopes*

	Disturbing circuit conditions	Disturbed circuit conditions
Deflection coefficient	Maximum value	That value which produces the maximum interaction
Time coefficient	A suitable value	
Applied signal	Sinusoidal at frequencies corresponding to each of the limits of the bandwidth of the disturbing circuit and to a value to be given by the manufacturer. Voltage to produce 80% of the rated deflection	

The minimum decoupling factor determined during successive tests shall be not less than the value given by the manufacturer.

31.2 *Interaction between x and y signals*

Under consideration.

31.3 *Phase difference between traces of a multi-trace oscilloscope*

	First channel Second channel
Vertical deflection coefficients	Suitable values
Time coefficient	Minimum value
Applied signal	Medium pulses according to Sub-clause 18.2*b)* applied equally and simultaneously to both inputs
Signal amplitude	To give 80% of rated deflection

The test is made for every possible combination of traces. The phase difference between the corresponding half-amplitude points of the pulses displayed on the two traces shall be less than the value indicated by the manufacturer in each case.

Note. — In the case of amplifiers using electronic channel switching, it is necessary to use external triggering unless the time base can be triggered internally from one of the two channels in use.

31.4 *Common-mode rejection factor of a difference-amplifying sampling oscilloscope*

Vertical deflection coefficient	Minimum value
Time coefficient	A suitable value
Applied signal (both inputs)	Sinusoidal at reference frequency, according to Sub-clause 18.1*c)*
Signal amplitude (both inputs)	Not more than allowed for the sampling oscilloscope being tested

The common-mode rejection factor shall be not less than that specified by the manufacturer.

The manufacturer shall also state the range of frequency and in-phase voltage for which a specified common-mode rejection factor is exceeded.

32. Apparent signal delay

Vertical deflection coefficient: a suitable value.
Time coefficient: set to allow the pulse front to be displayed.

Input signal: positive or negative short pulses, according to Sub-clause 18.2*a)*.
Signal amplitude: to produce 80% of the rated vertical deflection.
Time positioning control(s): set to cause maximum apparent delay.

Sampling mode: sequential and/or random.
Triggering: internal.

Apparent signal delay is measured as the horizontal distance between the start of the trace and the point at which the pulse display reaches 10% of its final amplitude. This distance is then converted to equivalent time by multiplication with the corresponding time coefficient.

The apparent delay(s) shall be not less than that (those) specified by the manufacturer.

Note. — The existence of the apparent signal delay depends partly on the type of vertical and/or horizontal plug-ins and also on the sampling modes used.

33. **Time positioning range**

Vertical deflection coefficient: a suitable value.

Time coefficient: a suitable value.

Input signal: medium pulse according to Sub-clause 18.2*b)*.

Signal amplitude: to produce 80% of the rated vertical deflection.

Sampling mode: sequential and/or random.

Triggering: internal.

The equivalent time corresponding to the range of maximum display shift produced by the time positioning control(s) is measured using the proper sampling mode.

The time positioning range shall be not less than that stated by the manufacturer.

Note. — The value of the time positioning range depends partly on the type of vertical and/or horizontal plug-ins and also on the sampling modes used.

SECTION FIVE — TIME BASE

34. **General**

Conditions for tests on the time base are similar to those for the deflection circuits. The test methods may, however, be different.

35. **Errors or variations of time coefficients**

35.1 *Operating error of time coefficients*

Time coefficients: all calibrated values.

The operating error over the interval between 10% and 90% of rated horizontal deflection shall not exceed the limit given by the manufacturer.

35.2 *Linearity error*

Time coefficient: all calibrated values.

Coefficients to be compared:

— the average time coefficient measured over the central 80% of the rated deflection;

— the average time coefficients determined in either of the two extreme 10% regions of the rated deflection.

The maximum error shall not exceed the limit given by the manufacturer.

The value of linearity error may depend on the setting of the delay control. Therefore, the manufacturer shall specify that part of the delay control(s) range beyond which the requirement will not apply.

35.3 *Influence errors or variations of time coefficients*

The following tests shall be performed to determine:

— the influence of the duration of applied mains supply voltage (see Sub-clause 25.2);
— the influence of mains supply voltage (see Sub-clause 25.3);
— the influence of mains supply frequency (see Sub-clause 25.4);
— the influence of ambient air temperature (see Sub-clause 25.5).

The influence errors or variations shall not exceed the limits given by the manufacturer.

36. Expansion

This test is performed only when calibrated indications are assigned to the expansion control by the manufacturer and applies to all calibrated positions of that control.

When the expansion control is operated, the time coefficient is measured between the points corresponding to 10% and 90% of the rated horizontal deflection.

The error of the time coefficient shall not exceed:

— when no error limit has been stated for the expansion control - the error limit stated for the deflection coefficient;
— when an error limit has been stated for the expansion control - the error limit for the deflection coefficient plus the expansion error limit.

SECTION SIX — DISPLAY STABILIZATION

37. Determination of display stabilization performance

The performance is defined for internal and external synchronization (or triggering) by:

— the synchronizing or triggering frequency range;
— the synchronizing or triggering threshold;
— jitter.

The values apply to the means by which the display is stabilized in the two cases:

— of a synchronized sweep;
— of a triggered sweep.

When an oscilloscope provides both of these facilities, tests are made for each of them.

38. Characteristics of synchronizing and triggering circuits

The tests to be performed are shown in Table III.

For the purpose of this clause, a stable display is one which has no more jitter than that specified by the manufacturer.

38.1 *Determination of the limits of the synchronizing or triggering frequency ranges*

The frequency of a sinusoidal voltage applied to the input circuit shall be increased in a continuous manner until it is no longer possible to obtain a stable display. The frequency corresponding to this point is the upper limit of the range.

The lower limit is found in similar fashion by decreasing the frequency of the signal applied to the input circuit.

The frequency range between these limits, having no gaps or discontinuities, shall be not less than that specified by the manufacturer.

38.2 *Determination of the synchronizing or triggering thresholds*

The following signals are used to determine the thresholds for both internal and external triggering:

— sinewave, according to Sub-clause 18.1*c)*;
— short pulse, according to Sub-clause 18.2*a)*;
— medium pulse, according to Sub-clause 18.2*b)*.

The minimum values required to maintain a stable display should be not greater than those given by the manufacturer.

Note. — The desirability of a threshold test using short pulses will be reconsidered in a future edition.

TABLE III

Characteristics of synchronizing and triggering circuits

<table>
<tr><th>Sub-clauses</th><th>Quantity to be determined</th><th>Synchronization or triggering source</th><th>Signal voltage</th><th>Vertical deflection coefficient</th><th>Results</th></tr>
<tr><td rowspan="2">38.1 and 38.3</td><td rowspan="2">Limits of synchronizing or triggering frequency range and time-base jitter</td><td>Internal</td><td rowspan="2">Sinusoidal voltage according to Sub-clauses 38.1 and 38.3</td><td>Minimum value</td><td rowspan="2">f min.: ... Hz
f max.: ... Hz
Jitter: ... ps</td></tr>
<tr><td>External [2]</td><td>Convenient value for observation</td></tr>
<tr><td rowspan="6">38.2</td><td rowspan="6">Synchronization or triggering thresholds</td><td rowspan="3">Internal</td><td>Sinusoidal voltage at the frequency given by the manufacturer</td><td rowspan="3">Minimum value</td><td rowspan="3">... mm peak-to-peak</td></tr>
<tr><td>Positive or negative [1] medium pulses</td></tr>
<tr><td>Positive or negative [1] short pulses</td></tr>
<tr><td rowspan="3">External [2]</td><td>Sinusoidal voltage at the frequency given by the manufacturer</td><td rowspan="3">Convenient value for observation</td><td rowspan="3">... V peak-to-peak</td></tr>
<tr><td>Positive or negative [1] medium pulses</td></tr>
<tr><td>Positive or negative [1] short pulses</td></tr>
<tr><td colspan="6">[1] The repetition rate of these pulses is constant and may have any value between 100 kHz and 1 MHz as convenient and in order to ensure a sufficient brightness of the trace.
[2] For external synchronization or triggering tests, the same signal is simultaneously applied to the input of the vertical amplifier and to the input of the external synchronizing or triggering circuit.</td></tr>
</table>

38.3 *Time-base jitter*

Tests are carried out in accordance with the conditions of Sub-clause 38.1, but with a signal having a frequency equal to the upper limit of the synchronizing frequency range and, unless otherwise specified by the manufacturer, having a level sufficient to produce a vertical deflection of 25% of the rated height of the display on the minimum deflection coefficient.

The tests are carried out at the minimum value of time coefficient which causes the fault to appear.

The time base jitter, expressed as a percentage of the rated horizontal deflection, shall not exceed, at the worst point of the display, the value specified by the manufacturer.

SECTION SEVEN — MISCELLANEOUS REQUIREMENTS

39. Geometry, orthogonality error and phase difference

39.1 *Geometry distortion*

The geometry distortion when determined according to the definition of Sub-clause 15.1 shall not exceed the limits given by the manufacturer.

Note. — When the measuring area is not rectangular, the manufacturer shall define a rectangle, taking the major dimensions of the measuring area.

39.2 *Orthogonality error in axial deflections*

This error is measured by applying two successive displacements, one of which is vertical and the other horizontal (see Sub-clause 15.2).

In the case of a multi-trace oscilloscope having a cathode-ray tube with a separate deflection system for each trace, the test is carried out on each of the traces.

The orthogonality error shall not exceed the limits given by the manufacturer.

Note. — An orthogonality error of 1 degree corresponds to a 1 mm displacement of the horizontal trace at a distance of about 5.7 cm.

39.3 *Parallelism error of multi-trace oscilloscopes*

The test is carried out as described under Sub-clause 39.2, but the angles between the horizontal traces (vertical traces) are measured.

The parallelism error shall not exceed the limits given by the manufacturer.

39.4 *Phase difference between vertical and horizontal displays*

The determination of this phase difference shall be made by applying the same sinusoidal signal to the terminals of the vertical and horizontal deflection circuits while being operated in the x-y mode.

The test shall be made at the extremes of the frequency range given by the manufacturer.

With no phase difference, a straight line will be observed on the screen.

With a phase difference, this straight line becomes an ellipse (see Figure 7, page 97). The value of the phase difference is given by the formula:

$$\sin \phi = \frac{h}{H}$$

where:

h = part of the vertical axis within the ellipse
H = height of the ellipse

The value so calculated shall be less than the value given by the manufacturer.

This only applies to sampling oscilloscopes which provide a sampling x-y display.

40. **Calibrating devices**

Tests on calibrating devices are performed under reference conditions and according to the instructions of the manufacturer. The accuracy of calibration shall be determined subsequently by checking the calibrated quantity according to the relevant sub-clauses of this standard.

41. **Electromagnetic radiation from oscilloscopes**

The magnitude of external electromagnetic radiation from oscilloscopes is determined under the following conditions:

The oscilloscope is set up on an insulating support without any earth connection and supplied with its rated voltage via a 150 Ω standard artificial-mains network according to IEC Publication 106, Recommended Methods of Measurement of Radiated and Conducted Interference from Receivers for Amplitude-modulation, Frequency-modulation and Television Broadcast Transmissions. The voltages across the terminals of this artificial-mains network are measured by means of a receiver which is tuned to the fundamental frequency of the sweep generator or of any other known possible source of r.f. energy (e.g. the e.h.v. generator) or to one of its harmonics. The artificial-mains network and the receiver are placed in the interior of screening cages which are connected to the earth potential of the test room.

Measurements shall be made for:

— the balanced and unbalanced interference voltages injected into the artificial mains network, by supplying the oscilloscope through a screened cable. One end of the outer sheath of the cable is connected to the enclosure of the oscilloscope and the other end to the earth of the test room;

the unbalanced voltage resulting from direct radiation from the oscilloscope, by supplying the mains connection through an unscreened cable having a screened suppression filter at the point of entry into the oscilloscope. The screen of this filter is directly connected to the oscilloscope enclosure.

The values so determined shall be less than the value given by the manufacturer.

42. **Brightness**

Under consideration.

43. **Luminance**

Under consideration.

44. **Dot slash**

It is determined by measuring the vertical deflection under the following conditions:

Vertical deflection coefficient: maximum value.

Time coefficient: a suitable value.

Dot density control: a suitable value.

Input signal: none.

Triggering: external — by medium reference pulse (see Sub-clause 18.2*b*)) with suitable amplitude at a repetition rate of 80 Hz.

The vertical deflection so measured, expressed in millimetres, shall not exceed the value stated by the manufacturer.

45. **Output signals related to the vertical (horizontal) deflections of the spot**

45.1 *Signal related to the vertical deflection*

This is a voltage corresponding to the vertical deflection and is determined under the following conditions:

Deflection coefficient: any value.

Time coefficient: a suitable value.

Spot position: at each of the two limits corresponding to 80% of the rated vertical deflection.

The voltage difference measured between the two spot positions shall be within the limits specified by the manufacturer.

45.2 *Signal related to the horizontal deflection*

This is a voltage corresponding to the horizontal deflection and is determined under the following conditions:

Time coefficient: any value.

Spot position: at each of the two limits corresponding to 80% of the rated horizontal deflection.

The voltage difference measured between the two spot positions shall be within the limits specified by the manufacturer.

SECTION EIGHT — METHOD OF EXPRESSION OF OSCILLOSCOPE CHARACTERISTICS

The form of specification for oscilloscopes to be provided by manufacturers, especially in data sheets and catalogues, shall as far as applicable be made in accordance with this section.

The detailed data contained in the specification shall be expressed in accordance with Sections Four to Seven of this standard.

When no limits are given for the value for a specified quantity, the value is considered to be approximate only.

List of technical data

Information to be provided			
Designation		Units	Remarks
46.	**General**		
	Manufacturer		Name and/or trade-mark
	Type		
	Purpose		Measurement oscilloscope
	Number of traces		Single trace/multi-trace Multi-beam tube Electronic switching
47.	**Tube**		
	Manufacturer		Name and/or trade mark
	Type		
	Number of beams		State whether multi-beam or split-beam
	Dimensions	mm	Diameter or diagonal of the face
	Measuring area	mm	Height, width
	Screen type		Fluorescent material and screen construction, aluminizing, etc.
	Total accelerating voltage	kV	
48.	**Types of sampling process**		Feed-through, real time/equivalent time, sequential/random, etc.
49.	**Functional units**		
49.1	*Plug-in units and probes*		State whether a plug-in arrangement is used and if probes are detachable
50.	**Warm-up time**	min	
51.	**Operating conditions**		
51.1	*Supply*		A.C. or d.c.
	Reference voltage	V	Or reference range
	Rated range of use	V	
	Reference frequency	Hz	Or reference range
	Rated range of use	Hz	
	Power consumption	VA	(Under reference conditions)
51.2	*Ambient air temperature*		
	Reference value	°C	Or reference range
	Rated range of use	°C	
51.3	*Relative humidity*		
	Rated range of use	%	State if wider than 0% and 80%
51.4	*Pressure*	kPA (kN/m^2)	State if $< 70\ kN/m^2$
51.5	*Reference frequency of signal voltage*	kHz, MHz	

Information to be provided			
Designation		Units	Remarks
52.	**Signal display**		
	Dot density	Number/cm Number/div	
52.1	*Deflection coefficients*	V/cm V/division	When the deflection coefficient is expressed in V/division or in cm/V, the manufacturer shall translate it into V/cm. Full range of values or minimum and maximum values.
	Limits of error	%	
	Linearity error limit	%	
	Limits of influence error of deflection coefficients due to:		Within the rated ranges of use
	— duration of applied supply voltage	%	After warm-up and 1 h later
	— changes of supply frequency	% per Hz	
	— changes of ambient air temperature	% per °C	
	— magnetic field of external origin	%	As a fraction of rated deflection
	Variation limits of deflection coefficients due to:		Within the rated ranges of use
	— changes of supply voltage:		For a 10% sudden change
	— transient variation	%	During the first minute
	— remaining variation	%	After 15 min
	— smoothing	%	
	Maximum permissible voltages:		
	— for all inputs	V	Without loss of performance
	— range of d.c. offset	V	With some loss of performance but without damage to the apparatus
52.2	*Instability of the spot position*		
	Long-term drift	mm/h	Also µV/h or mV/h
	Short-term drift	mm	Also µV or mV
	PARD:		
	— with smoothing	V	
	— without smoothing	V	
	Shift due to supply voltage change		For a 10% sudden change
	— transient shift	mm	During the first minute
	— remaining	mm	After 15 min
52.3	*Response*		
	Frequency ranges:		
	— rated range of use	Hz	For specified variation (see Sub-clause 28.1*a)*)
	— extended range of use	Hz	For 10% variation (see Sub-clause 28.1*b)*)
	— bandwidth of −3 dB	Hz	The rise time and bandwidth will vary as the dot density is varied if smoothing is applied
	Rise (fall) time:	ns, ps	
	— with smoothing		
	— without smoothing		
	Overshoot	%	
	Pulse tilt	%	
	Sustained step response	%	
52.4	*Positioning (vertical/horizontal)*		The range of control as a multiple of the rated deflection

Information to be provided			
Designation		Units	Remarks
52.5	*D.C. offset*	V	
52.6	*Input characteristics*		
	Input impedance	Ω	At d.c.
	S.W.R.		Maximum value
	Strobe emission	mV	
	Trigger emission	mV	
52.7	*Interaction*		
	Single-trace oscilloscopes:		For inputs as applicable Full conditions to be specified in accordance with Clause 31
	— decoupling factor		
	Multi-trace oscilloscopes:		For all combinations of inputs
	— decoupling factor		
	— phase difference	ns, ps	
	Difference amplifying oscilloscopes:		
	— common mode rejection factor		
	— maximum in-phase signal	V	
	Operating facilities		Algebraic sum ...
52.8	*Delay line*		State if any and if fitted the type of construction design
	Apparent signal delay	ns, ps	
	Time positioning range	μs, ns, ps	
52.9	*Electronic switching*		
	Type of switching		Alternate, chopped
	Switching rate	Hz	State as applicable
52.10	*Other facilities*		
	Auxiliary outputs	V cm	State internal resistance and the voltages per centimetre of deflection
53.	**Time base**		
53.1	*Sweep*		
	Manner of time deflection		For example: linear/logarithmic/sinusoidal, real time/equivalent time, random sweep
	Operating modes		Free running, triggered, single display, manual, by external source
	Hold-off circuit		State if any
	Delayed sweep		State if any
	Delaying sweep		State if any
	Trace blanking		State if any and whether blanking is by suppression or deflection of the beam
53.2	*Time coefficients*		Full range of values or maximum and minimum values; fine controls, if any
	Coefficient error limit	%	
	Linearity error limit	%	
	Influence error limits of time coefficients due to:		
	— duration of applied supply voltage	%	After warm-up and 1 h later
	— changes of supply frequency	% per Hz	
	— changes of ambient air temperature	% per °C	

Information to be provided			
Designation		Units	Remarks
	Variation limits of time coefficient due to:		
	— changes of supply voltage:		For a 10% sudden change
	transient variation remaining variation	% %	During the first minute After 15 min
53.3	*Magnification (expansion)*		
	Effect of control		Continuously variable or switched; calibrated or uncalibrated
	Error	%	Additional or total
54.	**Display stabilization**		
54.1	*Operating mode*		Synchronized sweep, triggered sweep internally and/or externally
54.2	*Synchronized sweep*		
	Synchronization frequency range	Hz	State values for internal and external operation, if different
	Synchronizing threshold: — for sinusoidal waves — for medium pulses — for short pulses	V peak-to-peak mm	External synchronization Internal synchronization
	Time base jitter	%	Of rated horizontal deflection
54.3	*Triggered sweep*		
	Operating mode		For example: normal, preset, automatic. State if different modes result in different operating values
	Trigger frequency range	Hz	State values for internal and external synchronization, if different
	Trigger threshold: — for sinusoidal waves — for medium pulses — for short pulses	V peak-to-peak mm	External triggering Internal triggering
	Time base jitter: — with smoothing — without smoothing	%	Of rated horizontal deflection
54.4	*Maximum permissible external triggering voltage*		Without permanent damage
55.	**Miscellaneous**		
55.1	*Geometry distortion*	mm	
	Orthogonality error	deg	
	Parallelism error	deg	
	Phase difference between horizontal and vertical displays	deg	In the x-y mode

Information to be provided			
Designation		Units	Remarks
55.2	*Additional controls*		
	Intensity modulation:		
	— frequency range	Hz	
	— blanking voltage	V	
	— input impedance	Ω, pF	
	Intensity modulation via amplifier:		
	— unblanking voltage and polarity	V	
	— input impedance	Ω pF	
	— frequency range	Hz	
	— d.c. coupled		State if so; if not, state time constant
55.3	*Calibration devices*		
	Type of device		Amplitude, frequency or time mark generator, if any
	Action of device		On vertical, horizontal deflections and sweep
	Accuracy	%	
55.4	*Electromagnetic radiation (radio interference)*		Determined according to IEC Publication 106
	Conducted interference:		
	— symmetrical		
	— asymmetrical		
	Radiated interference		
55.5	*Graticule*		Internal, external
	Arrangement		Fixed, removable, rotatable, adjustable
	Size and engravings		
	Illumination		State how achieved
55.6	*Additional devices*		State if any and give details as applicable
	For example:		
	— cathode-ray tube alignment		
	— beam finder		
	— digital indicating devices		
	— display storage		
	— battery operated		
55.7	Safety class		According to IEC Publication 348. In case of Class I, state kind of earth connection
55.8	Mechanical features		
	Design		For example: portable, trolley mounting, rack mounting
	Dimensions	mm	Over-projections
	Mass	kg	Normal accessories included
55.9	Cooling		Natural/forced
55.10	Valve (or tube)/solid state device replacement		State whether normal or selected

SECTION NINE — MARKING

56. Data presented on the sampling oscilloscope

56.1 On the visible outer surface of the sampling oscilloscope shall appear:

— manufacturer's name and/or trade-mark;

— type or model designation;

— rated supply voltage and, in case of a.c. supply, rated supply frequency.

56.2 The rating and nature of the fuse shall be marked beside or on the fuse holder if replaceable fuses are used. If the oscilloscope is intended for several supply voltages and current ratings cannot be marked for lack of space, it will be sufficient if they are indicated in the instruction manual.

56.3 Terminals and operating devices shall be identified by one of the following methods:

— a marking stating clearly the intended purpose;

— an abbreviated marking corresponding to information in the instruction manual.

Terminals shall, as far as possible, also be clearly identified as to impedance, polarity, voltage and, if applicable, the form and magnitude of the signals to be applied or available.

Operating devices should be equipped with a dial or scale to indicate clearly the values and/or operating modes obtainable in their different positions.

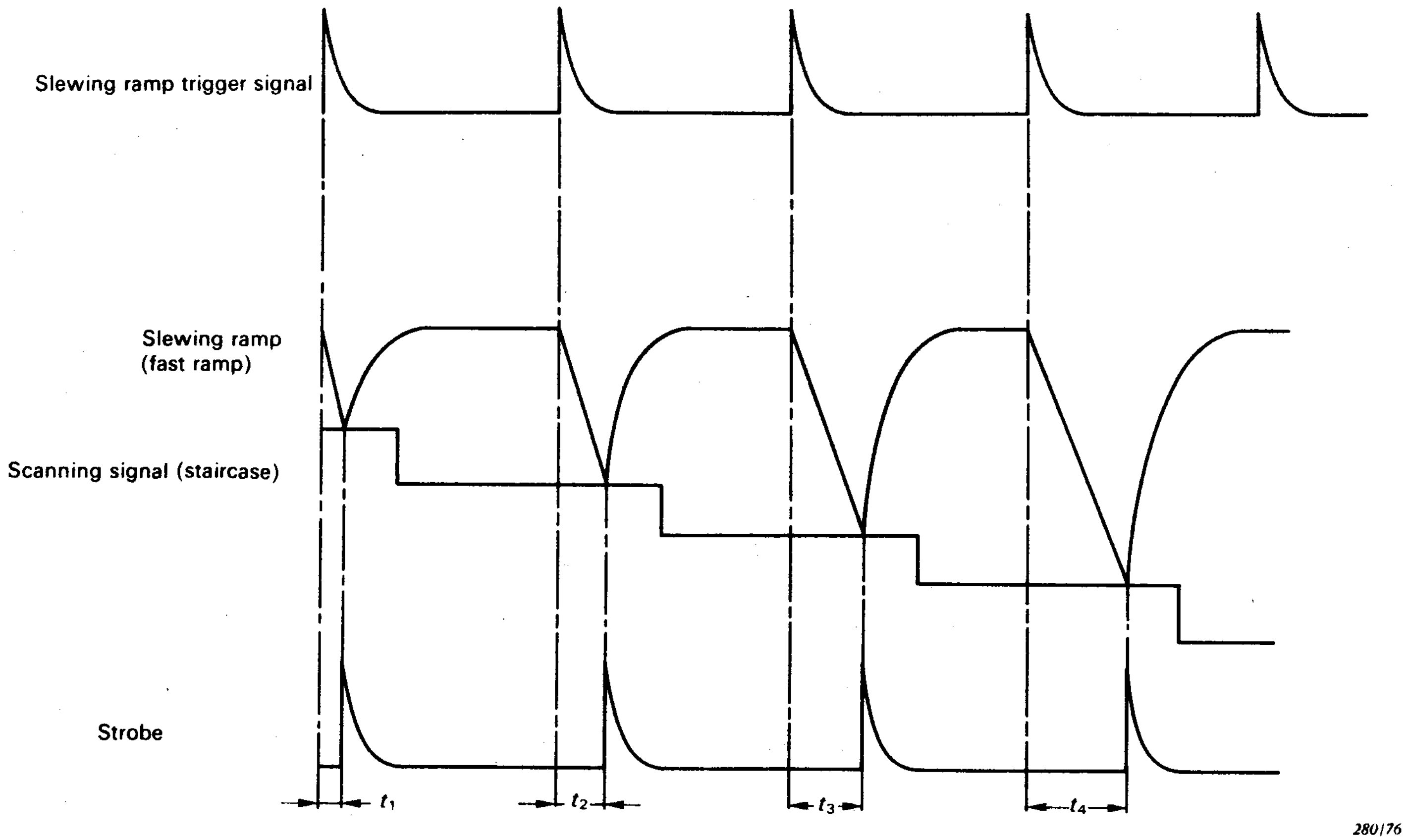
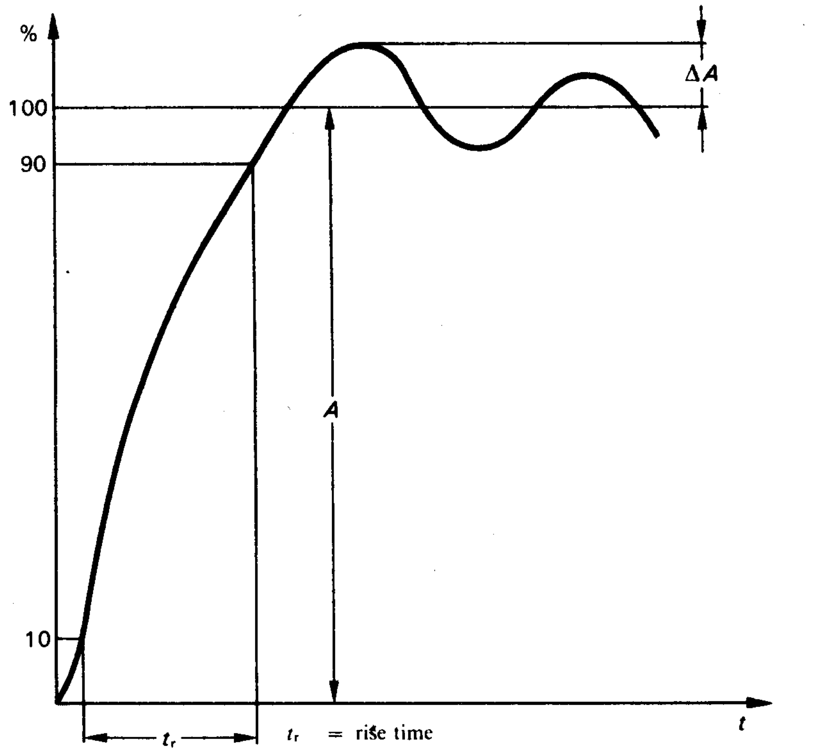

Slewing ramp trigger signal
Slewing ramp
(fast ramp)
Scanning signal (staircase)
Strobe
t_1
t_2
t_3
t_4
280/76

FIGURE 1



t_r = rise time

$\frac{\Delta A}{A}$ = overshoot

FIGURE 2

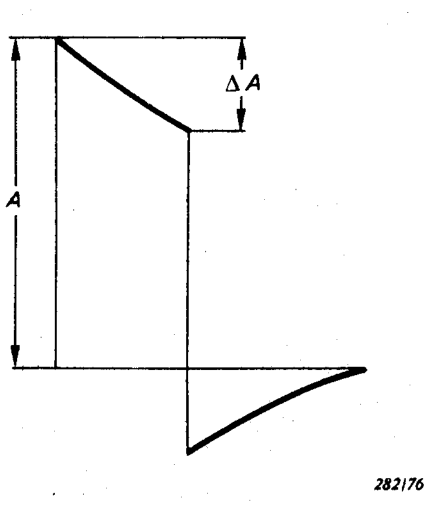


FIGURE 3*a*

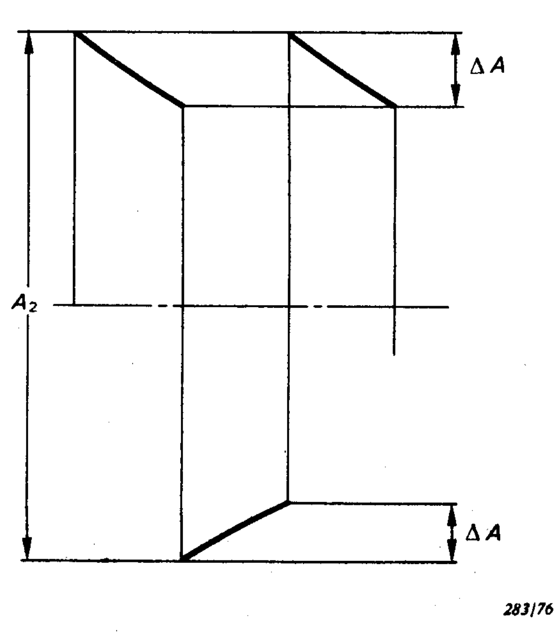


FIGURE 3*b*

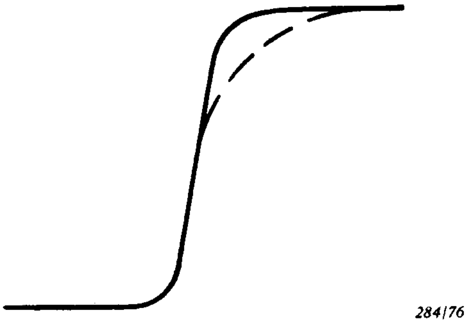


FIG. 4a. — Rounding.

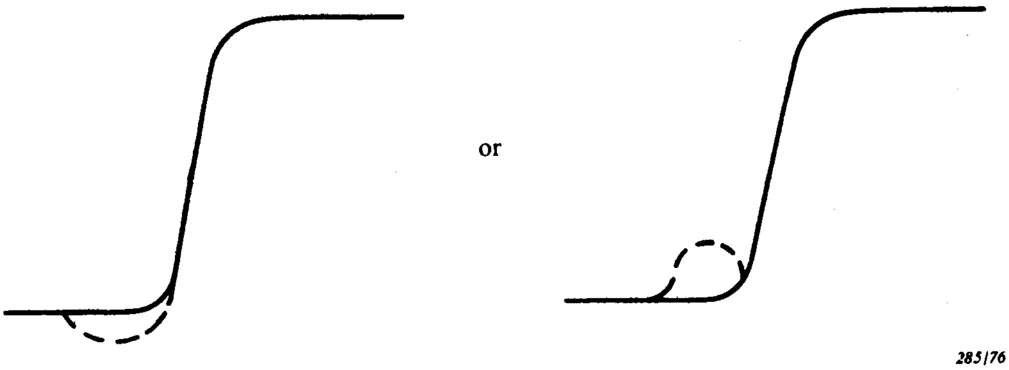


FIG. 4b. — Pre-shoot.

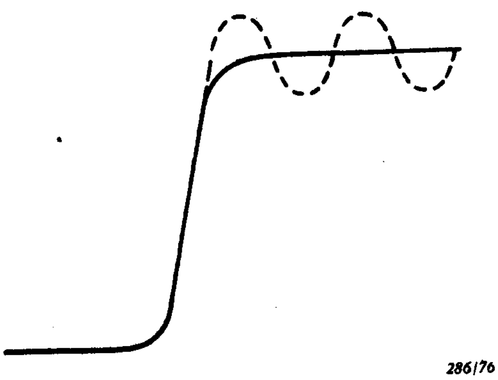


FIG. 4c. — Ringing.

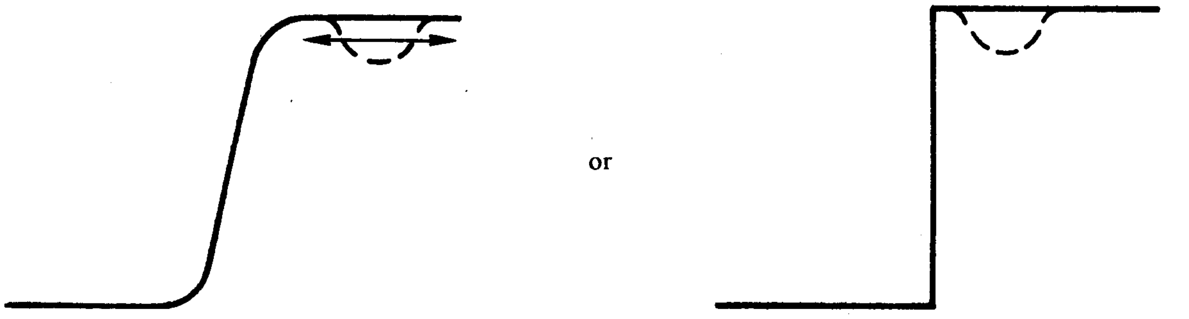


FIG. 4*d*. — Holes.

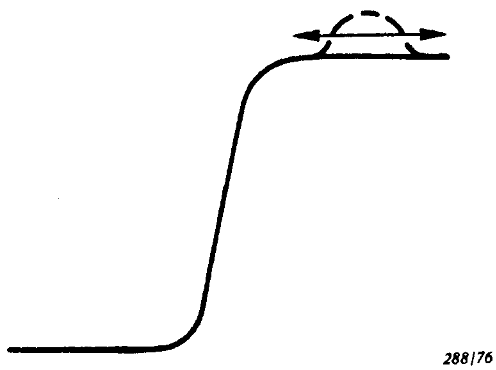


FIG. 4*e*. — Bump.

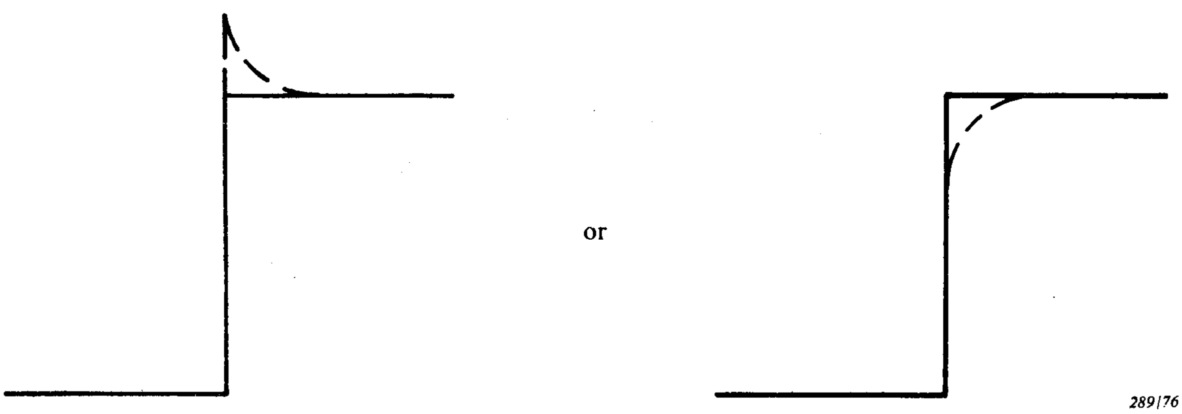


FIG. 4*f*. — Effects of maladjustment of the input attenuator.

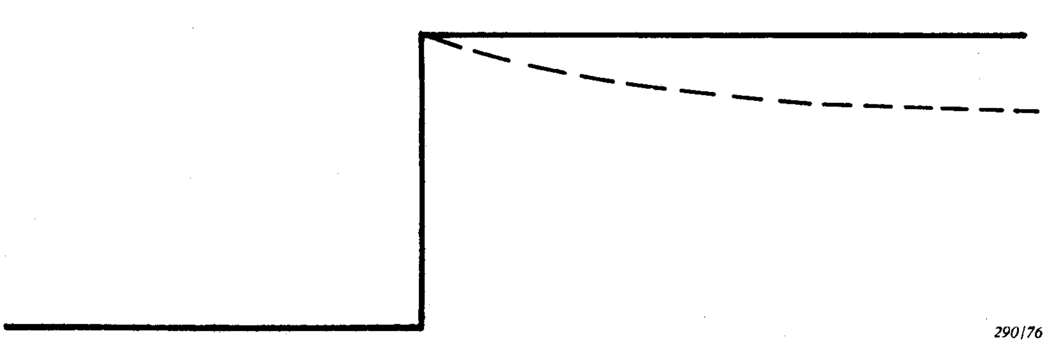
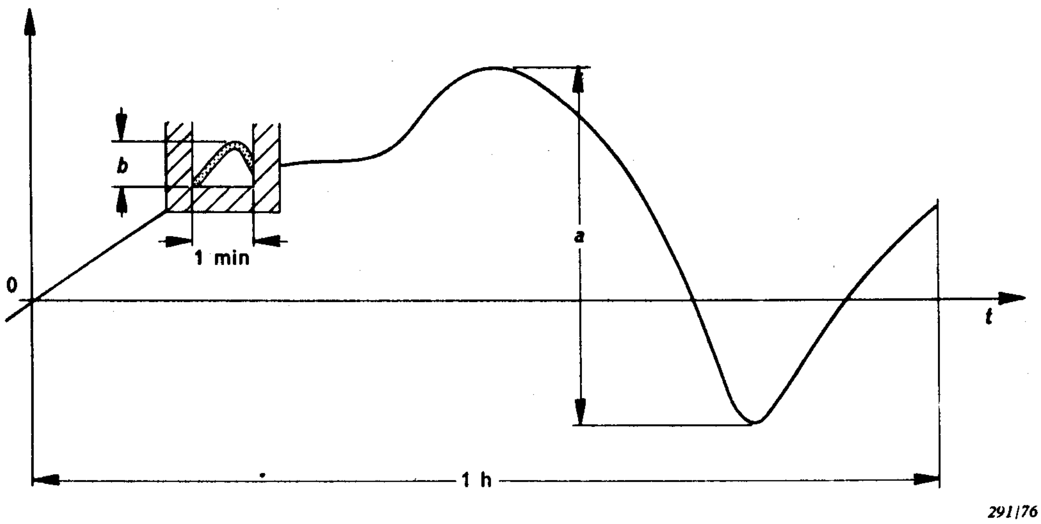


FIG. 4*g*. — Defects of sustained step response.



a = long-term drift

b = short-term drift

FIG. 5. — Vertical (horizontal) drift.

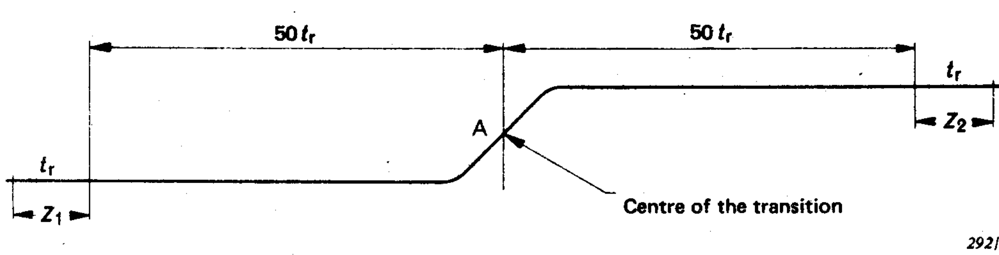


FIG. 6.— Long reference pulse.

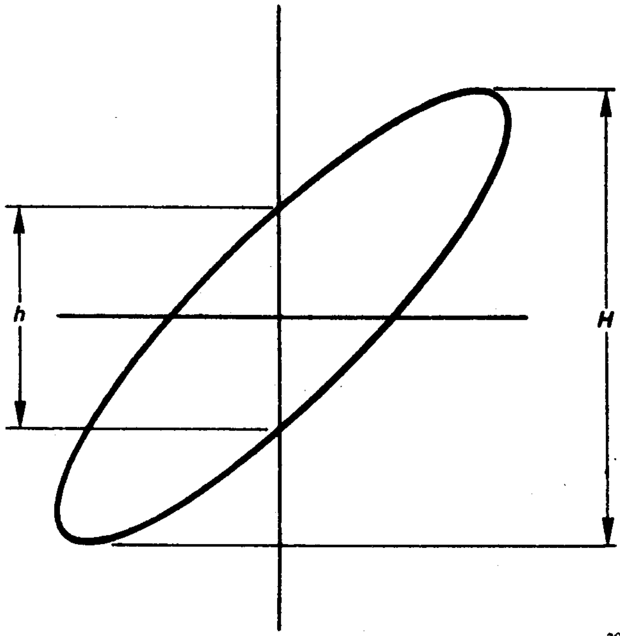


FIGURE 7